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(71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventors: GIANNOPOULOS, Demetri; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). WANG, Shenghong; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: BOSMA, Rudolphus, H., A.; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

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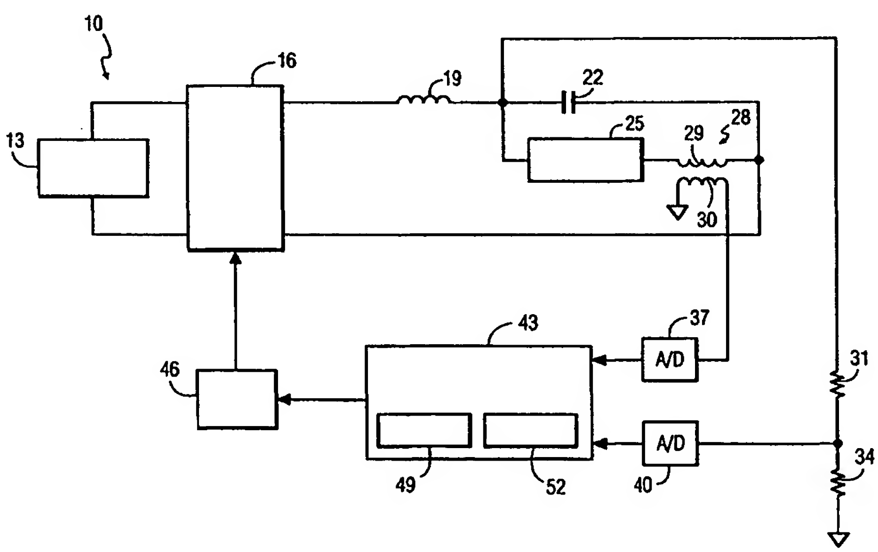

(57) Abstract

A ballast for operating different types of lamp loads (25) through identification of the lamp type during steady state operation of the lamp load (25). Lamp type recognition is achieved based on a comparison of the lamp load voltage and lamp load current data points stored in a random-access memory (49) of a microprocessor (43) to a plurality of V-I characteristic curves stored in a read-only memory (52) of the microprocessor (43). Through this comparison, the ballast (10) can distinguish among a number of different lamp loads (25) having the same starting voltage.

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Electronic ballast.

This invention relates generally to an electronic ballast and, more particularly, to a scheme for identifying the type of fluorescent lamp which is being powered by the electronic ballast.

There are many different types of fluorescent lamps including preheat and rapid start. Not only do each of these lamp types have different ratings for ignition and/or steady state operation but within each lamp type there are different ratings for ignition and/or steady state operation. These differences can be expressed, in part, by voltage-current (V-I) characteristic curves. A ballast inverter should be driven based on the V-I characteristic curve of the lamp.

A typical ballast is designed to supply a specific starting voltage and load current based on the V-I characteristic curve of the lamp to be powered by the ballast. Different ballasts are therefore required based on the lamp load to be powered. No one ballast can be used for all these different types of lamps. With the increasing number of lamps available, more and more different types of ballasts are required. Many of these lamps are produced in relatively small numbers, making the manufacturing cost for the associated ballast relatively high. Ballasts designs are further complicated by the number of different ballasts designs required.

One approach which has been proposed in attempting to solve the foregoing problems, as disclosed in U.S. Patent No. 5,039,921, identifies the lamp to be powered based on the lamp's starting voltage. Three different types of V-I characteristic curves are stored in and can be accessed from a memory based on the lamp's starting voltage. The accessed V-I characteristic curve is used in driving the ballast inverter. Unfortunately, many lamps have the same or about the same starting voltage and therefore cannot be distinguished from each other based on the starting voltage. The starting voltage also changes during the lifetime of the lamp thereby complicating recognition of the lamp based on starting voltage.

It is therefore desirable to provide an improved electronic ballast which can power a number of different types of lamp loads. The improved ballast should be able to distinguish among a number of different lamp loads having the same starting voltage.

In accordance with a first aspect of the invention, a method for operating a ballast includes the steps of providing a sufficient starting voltage for ignition of a lamp load, adjusting the lamp load current to at least two different levels, measuring the lamp load voltage corresponding to each of the at least two different lamp load current levels, comparing the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves, selecting the curve which best matches these at least two different levels, and operating the ballast based on the selected curve.

The ballast can power a number of different types of lamp loads through identification of the lamp type during steady state operation of the lamp load. Lamp type recognition is achieved based on a comparison of the lamp voltage and lamp current to a plurality of V-I characteristic curves. Through this comparison, the ballast can distinguish among a number of different lamp loads having the same starting voltage.

It is a feature of the invention that the method further includes storing the lamp load current and associated lamp load voltage for each of these at least two different levels and plurality of lamp V-I characteristic curves in a microprocessor. In another feature of the invention, the method further includes producing switching signals to an inverter from a driver based on a signal outputted from the microprocessor. Preferably, the at least two different levels of lamp load current are less than 50% of the nominal current rating of each of the lamp loads that can be powered by the inverter.

In accordance with a second aspect of the invention, a ballast includes an inverter responsive to switching signals for powering one of at least two different lamp loads wherein each lamp load has a different V-I characteristic curve. The ballast also includes a microprocessor and a driver responsive to the microprocessor output signal for generating the switching signals. The microprocessor adjusts the current flowing through the lamp load to at least two different levels following ignition of the lamp load, measures the lamp load voltage corresponding to each of the at least two different lamp load current levels and compares the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves. The microprocessor produces the microprocessor output signal based on the curve which best matches these at least two different levels.

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a partial block diagram and partical electrical schematic in accordance with the invention;

Fig. 2 is a flow chart of a lamp recognition scheme;

Fig. 3 is a plot illustrating several V-I characteristics curves; and

Figs. 4A and 4B are plots of the lamp voltage and lamp current versus time, respectively.

As shown in Fig. 1, a ballast 10 includes a DC source 13 which supplies a substantially DC voltage or current to an inverter 16, the latter of which can be of the full bridge or half bridge type. A high frequency pulse train, which can vary in frequency and/or pulse width, is supplied to a series resonant LC circuit which includes an inductor 19 and a capacitor 22. A serial combination of a lamp load 25 and a primary winding 29 of a current transformer 28 is connected in parallel across capacitor 22. The series resonant LC circuit filters the pulse train so as to apply a substantially high frequency sinusoidal waveform to lamp load 25.

A voltage divider formed from a serial combination of a pair of resistors 31 and 34 is connected between ground and a junction joining inductor 19 to capacitor 22. The current flowing through lamp 25 (i.e. ILAMP) is sensed by a secondary winding 30 of transformer 28 and applied to an analog to digital converter (A/D) 37. The voltage across the serial combination of lamp load 25 and primary winding 29, which is essentially the voltage across lamp load 25 (i.e. VLAMP), is sensed by the voltage divider and applied to an analog to digital converter (A/D) 40. A pair of digital signals representing ILAMP and VLAMP are supplied by converters 37 and 40, respectively, to a microprocessor 43.

Microprocessor 43 outputs a signal to a driver 46, the latter of which in response to the microprocessor output signal controls the frequency and/or pulse width of the switching signals supplied to inverter 16. These switching signals determine the frequency and/or pulse width of the pulse train outputted by inverter 16. During steady state operation of lamp load 25, the microprocessor output signal reflects the V-I characteristic curve of lamp load 25.

The V-I characteristic curve chosen by microprocessor 43 is based on a sequence of steps as shown in FIG. 2. Under a step 101, lamp load 25 first passes through ignition. Once lamp load 25 is in its steady state mode of operation, under a step 104 microprocessor 25 sets the value of i=1. Under a step 107, the microprocessor output signal now reflects setting the value of ILAMP=ILAMPi. The switching signals produced by driver

46, which are supplied to inverter 16, in response to the microprocessor output signal result in ILAMP=ILAMPi. Under a step 110, the value of VLAMPi is now measured by microprocessor 43 based on the signal produced by A/D 40. The values of VLAMPi and ILAMPi are temporarily stored in a random access memory. The value of i is checked under step 113 to determine if i=n, where n is equal to at least 2. In the event that i is not yet equal to n, the value of i incremented by a value of 1 under step 116. Steps 107 through 116 are repeated until under step 113 i=n. The lamp type is then determined by microprocessor 43 under step 119. Assuming n=3, three different sets of VLAMP and ILAMP values stored in memory 49 are compared to the plurality of V-I characteristic curves stored in a read-only memory 52. The V-I characteristic curve which best matches the values of VLAMPi and ILAMPi is chosen by microprocessor 43 and used in producing the microprocessor output signal.

A sample of the V-I characteristic curves stored in memory 52 is illustrated in Fig. 3. Four V-I characteristic curves 201, 204, 207 and 210 represent nominally rated 40 watt, 36 watt, 24 watt and 18 watt fluorescent lamps, respectively. The curves stored in memory 52 should include curves for all of the different types of lamps which ballast 10 could be expected to power. The value of n should be chosen so that there are a sufficient number of VLAMPi and associated ILAMPi values from which to choose among the plurality of curves stored in memory 52. In other words, the value of n can be, if required, greater than n=2. All values of ILAMPi set by microprocessor 43 are less than the nominal current rating of lamp load 25 (i.e. current rating of lamp load 25 at full illumination) in order to protect the latter from damage. Preferably, ILAMPi+1 is greater than ILAMPi such that ILAMPn is the highest value of ILAMP set by microprocessor 43. In one preferred embodiment of the invention when n=3, ILAMP1, ILAMP2 and ILAMP 3 are chosen so as to be equal to 25%, 35% and 45% of the nominal current rating of the lamp load that has the highest nominal current rating of all the lamp loads that can be operated by the ballast, respectively.

Referring now to Figs. 4A and 4B, the values of VLAMP (Fig. 4A) and ILAMP (Fig. 4B) are plotted for n=3. As shown in Fig. 4A, the voltage across lamp load 25 is raised until lamp load 25 ignites at time t1. Following ignition, the voltage across lamp load 25 decreases and the level of current flowing in lamp load 25 increases. Lamp load 25 is now in its steady state of operation. At time t2, microprocessor 43 has set ILAMPi to a value of I1. The value of VLAMP (i.e. V1) is determined by microprocessor 43 based on the signal produced by A/D 40 and stored within memory 49. Microprocessor 43 at time t3 has set ILAMPi to a value of I2, determines the value of VLAMP (i.e. V2) and stores the latter in

memory 49. Microprocessor 43 at time t4 has set ILAMPi to a value of I3, determines the value of VLAMP (i.e. V3) and stores the latter in memory 49. The three different sets of VLAMP and ILAMP values stored in memory 49 are now compared to the plurality of V-I characteristic curves stored in memory 52. The V-I characteristic curve which best matches the values of VLAMPi and ILAMPi is chosen by microprocessor 43 and used in producing the microprocessor output signal.

The level of lamp current I3 is substantially less than the current level at full illumination (i.e. denoted as "max light") for lamp load 25. Operation of lamp load 25 in regions near or above its nominal rating is thereby avoided. Once lamp load 25 has been identified, microprocessor 43 adjusts the lamp current to a desired level as determined by the user. For example, when ballast 10 is used in combination with a dimmer (not shown), microprocessor 43 will control the level of lamp load illumination to the level set by the dimmer including, if desired, to the lowest level of illumination possible.(denoted as "min light").

As can now be readily appreciated, ballast 10 can power a number of different types of lamp loads through identification of the lamp type during steady state operation of lamp load 25. Lamp type recognition is achieved based on a comparison of the lamp voltage and lamp current data points stored in memory 49 to the plurality of V-I characteristic curves stored in memory 52. Through this comparison, ballast 10 can distinguish among a number of different lamp loads having the same starting voltage.

It will thus be seen that the objects set forth above and those made apparent from the preceding description are efficiently attained and since certain changes may be made in the above construction without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

CLAIMS:

1. A method for operating a ballast (10) in dependency of a lamp load connected to the ballast comprising the step of:

providing a sufficient starting voltage for ignition of a lamp load (101);

characterized in that the method further comprises the steps of:

adjusting the lamp load current to at least two different levels (107,116);

measuring the lamp load voltage corresponding to each of the at least two different lamp load current levels (110);

comparing the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves (119);

selecting the curve (201, 204, 207, 210) which best matches these at least two different levels; and

operating the ballast based on the selected curve.

2. The method of claim 1, further including storing the lamp load current and associated lamp load voltage for each of these at least two different levels and a plurality of lamp V-I characteristic curves in a microprocessor (43).

3. The method of claim 2, further including producing switching signals to an inverter (16) from a driver (46) based on a signal outputted from the microprocessor (43).

4. The method of claim 1, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.

5. The method of claim 3, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.

6. A ballast (10), comprising:

an inverter (16) responsive to switching signals for powering one of at least two different lamp loads, each lamp load (25) having a different V-I characteristic curve;
a driver (46) responsive to a microprocessor output signal for generating the switching signals; and;

a microprocessor (43) for generating the microprocessor output signal in dependency of a lamp load connected to the ballast,
characterized in that the microprocessor is programmed for adjusting the current flowing through the lamp load to at least two different levels following ignition of the lamp load, measuring the lamp load voltage corresponding to each of the at least two different lamp load current levels, comparing the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves (201, 204, 207, 210) and selecting the curve which best matches these at least two different levels and producing the microprocessor output signal based on the selected curve.

7. A ballast according to claim 6, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.

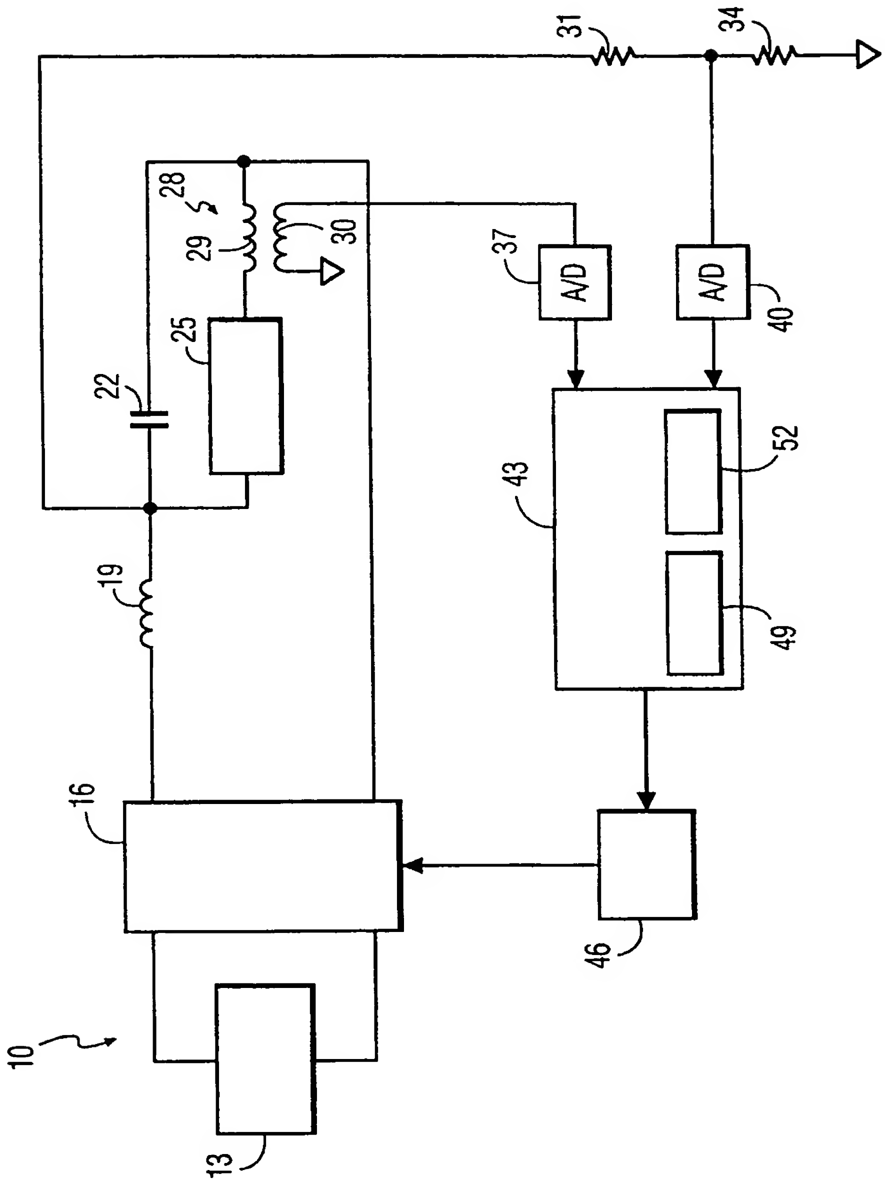

FIG. 1

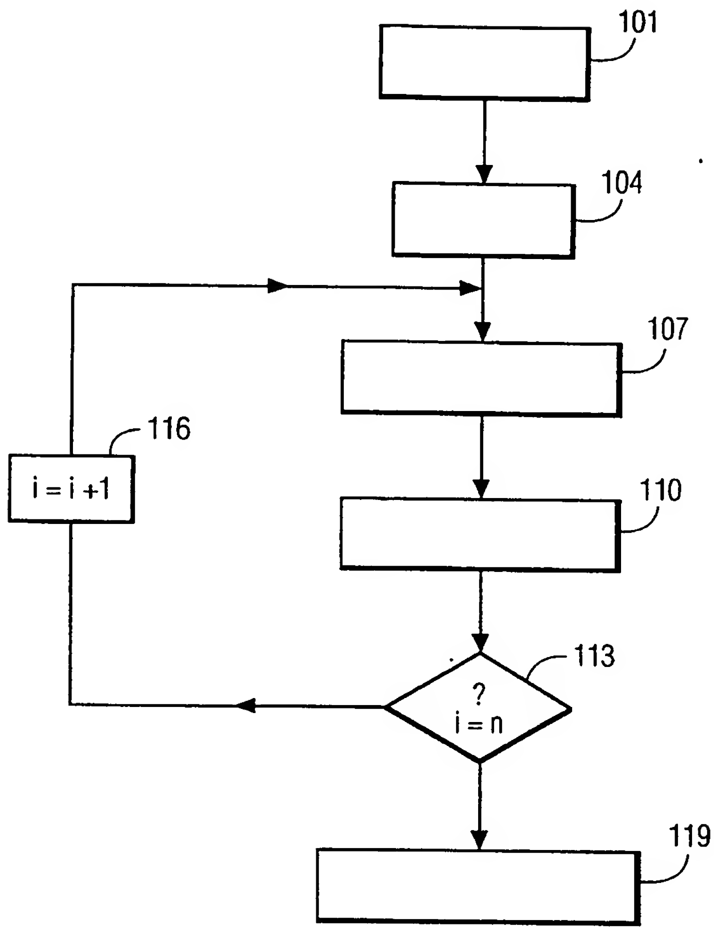

FIG. 2

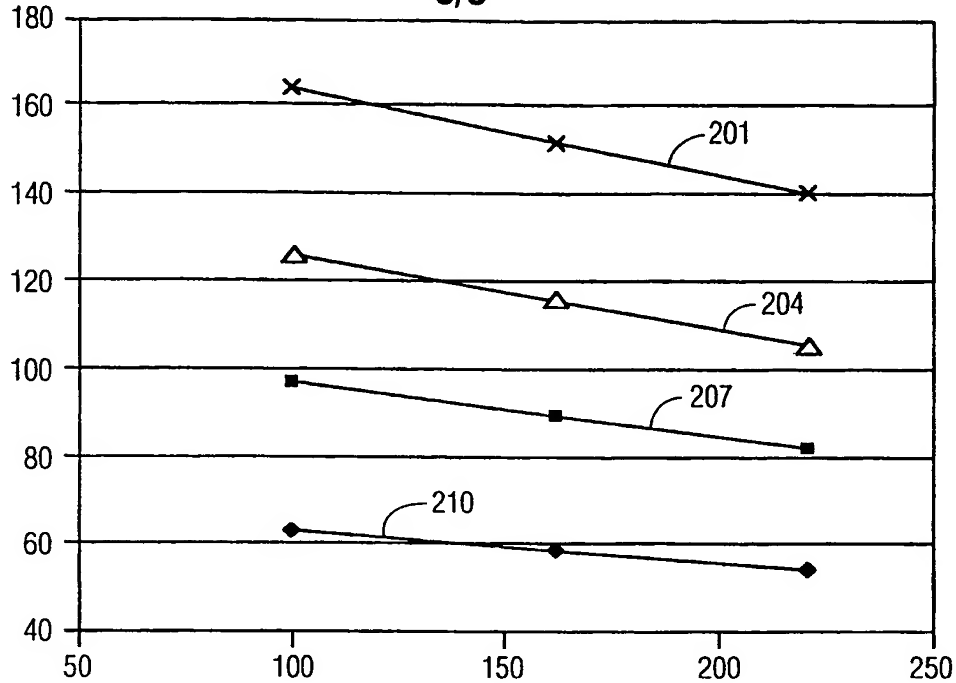

FIG. 3

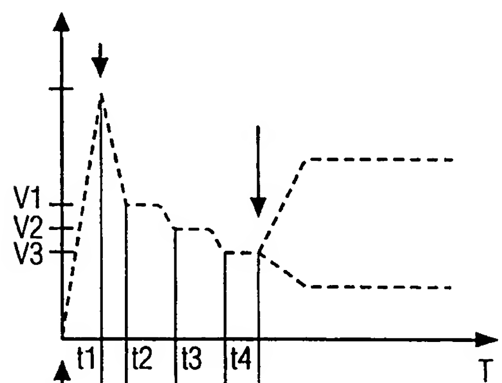

FIG. 4A

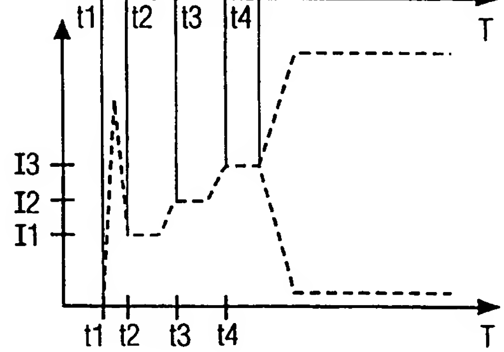

FIG. 4B

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 99/05035

A. CLASSIFICATION OF SUBJECT MATTER

H05B41/36

According to International Patent Classification (IPC) or to both national classification and IPC 7

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI, Week 199525, Derwent Publications Ltd., London, GB; Klasse H05B, AN 1995-188703; & JP 07 106088 A (ORIGIN ELECTRIC), 21 April 1995, abstract. --	1,6
A	EP 0127101 A (SIEMENS AG) 05 December 1984, abstract, claims, fig.. --	1,6
A	EP 0637195 A (S.A. METAS) 01 February 1995, abstract, claim 3, fig.. ----	1,6

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 November 1999	21 12 1999

Name and mailing address of the ISA	Authorized officer
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ANHANG

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

ANNEX

to the International Search Report to the International Patent Application No.

ANNEXE

au rapport de recherche international relatif à la demande de brevet international n°

PCT/EP 99/05035 SAE 243641

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